COAL-FIRED FLY ASH

SCOPE OF THE DOCUMENT

This document focuses on the hazards of coal-fired fly ash. The toxicological and radiological hazards of fly ash are described. Information relevant to the workplace is emphasized. Special attention is given to the main hazard presented by fly ash. Details of exposure controls are given.

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COAL-FIRED FLY ASH--CHEMICAL HAZARD SUMMARY NO. 40

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I. MAIN HAZARD

The main hazard of coal-fired fly ash is irritation of the eyes, nose and throat.

II. OCCUPATIONAL EXPOSURE

Fly ash is the general name given to ashes that are produced from burning coal. Electrical power utilities which burn coal to generate electricity produce several million tons of fly ash each year. The majority of the ash produced is collected by scrubbers and precipitators and is not released into the atmosphere. Five per cent or less of the ash produced during coal combustion is released into the atmosphere.

Until recently, most of the ash was disposed of in landfill sites. However, there is an increasing trend to recycle fly ash and add it to various products as a "filler." The construction industry has been using fly ash as an additive to Portland cement. Between 10 and 65 per cent of Portland cement can be composed of fly ash.

Fly ash could be added as a filler in paints and coatings, rubbers, plastics, putty, caulking, sealants, dry wall jointing compounds, adhesives and carpet backings. Although many of these applications are at the experimental stage, studies suggest that up to 60 per cent of the composition of some of these products could be made up of fly ash filler.[1] These new applications of fly ash will increase the number of people exposed.

From the toxicological viewpoint, fly ash is in its least hazardous form when it is bound as a solid with other compounds. Fly ash is in its most hazardous form when it exists as a dust that can be inhaled or perhaps swallowed through contamination of food or cigarettes. Skin absorption and eye contact are not important routes of exposure to fly ash.[2]

Fly ash dust particles usually must be extremely small (smaller than 5 μm) in order to enter the inner recesses of the lungs. A few particles up to 10 μm in size reach the inner lung areas. However, nearly all particles above 10 μm are trapped in the nasal passages, throat, larynx, trachea and bronchi.

The proportion of a fly ash sample that contains particles of inhalable size varies according to the type of coal and the way in which it was burned. In some samples, about 25 per cent of the particles are of the size which could be inhaled and retained by the lungs.[3]

Concerns about exposure to fly ash come from the nature of its composition. Uncertainties about health effects have focused on the presence of "glass-like" aluminosilicates and various inorganic and organic contaminants. High doses of inorganic contaminants such as metals can cause health problems. As well, some of the organic chemicals are suspected carcinogens.

Other health concerns about fly ash exposure relate to its origins from coal. Certain coals, like some minerals and ores derived from the earth, have a natural or "background" radioactivity. When coals are burnt, the ash produced concentrates the radioactivity. The ash might pose a radiation health hazard.

Fly ashes are highly variable in their chemical composition and radioactivity. This variability is due to the use of different types of coals and different burning processes in power plants.

III. HEALTH HAZARDS

Removal from the Body

A large proportion of fly ash particles which are breathed into the lungs are also breathed out.[4,5] Particles of 10 μm and greater are trapped in the mucus which lines the nasal passages, throat and larynx. These particles are then carried in the mucus to the back of the mouth where they are spat out or swallowed. In animal studies, it takes three days for removal of half of the inhaled fly ash from the airways.

Particles which find their way to the inner recesses of the lungs take longer to be removed. Any portion of the fly ash particle which is soluble in body fluids is absorbed through the lung tissue and passes into the blood stream where it is distributed in the body. Studies with rats exposed to high concentrations of fly ash 6 hours a day for 15 days showed higher concentrations of several metals in the lungs, liver, kidneys, heart, small intestine and blood. These elevated concentrations began to decline when exposure stopped, but were still evident after 30 days.[6]

Most of the fly ash particle is normally not soluble in body fluids and remains deposited in the lung until the body's defence cells attempt to digest and remove it. Studies in which hamsters inhaled fly ash show that it takes 35 days for removal of half of the ash deposited in deep areas of the lungs. After 99 days, only 10 per cent of the original fly ash is still present. Estimates suggest that complete clearance would take approximately 200 days.[4] Similar studies with rats inhaling fly ash show that it takes 78 days for half the ash to clear from the lungs.[7]

Effects of Short-Term Exposure in Humans

Inhalation

Breathing in large quantities of fly ash causes irritation and dryness of the nose and throat.

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Eyes

Heavy fly ash dust concentrations cause irritation and soreness of the eyes.

Skin

There are no reported effects of fly ash on the skin.

Ingestion

There are no reports of toxic effects from swallowing fly ash.

Effects of Long-Term Exposure in Humans

Carcinogenic Effects

Although fly ash contains very small amounts of chemicals that are suspected carcinogens, there is little indication that it presents any cancer risk to humans. No case history reports or population studies suggest that inhalation of fly ash presents a cancer risk.

Cancer is a known consequence of long-term exposure to ionizing radiation. There are some indications that fly ash may have radioactivity up to ten times the amount found naturally in coal. Even so, this is still a low level and is often lower than some natural activity found in certain rock formations. The levels of activity emitted from raw fly ash, or fly ash used as a filler in industrial products, are below the exposure limits recommended by the International Commission for Radiological Protection (ICRP). In many instances, natural background radiation is higher than that found in fly ash or products using fly ash as a filler.

Effects on the Lungs

Fly ash from different sources contains different quantities of crystalline free silica (quartz). Many types contain less than 5 percent of quartz, but a few have been shown to contain up to 15 per cent. Long-term inhalation of quartz particles produces a devastating and progressive lung disease known as silicosis. This disease has been particularly prevalent in people employed in ore mining and refining operations.

However, quartz found in fly ash has a physical form quite different to that found in mining operations. Quartz in fly ash is "fire-polished"; that is to say, it has no jagged edges and consists of smooth balls that resemble tiny glass beads. Quartz in this form is not considered to present the same hazard as the more usual forms of crystalline quartz.[8]

There is one report of a worker who developed scar tissue in the lungs after long-term exposure to fly ash. Post-mortem examination revealed a large number of fly ash particles in the lungs. However, the picture was not clear-cut since there were also large numbers of asbestos fibres present. Asbestos is a known lung-damaging agent.

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A further concern about fly ash relates to its dusty nature. It has been suggested that it may cause "dusty lung disease." This is a condition caused by the build-up of relatively non-toxic dusts in the lungs. A single study on people exposed to fly ash reported there was no dusty lung disease in these particular workers.

Toxicity Data in Animals and Laboratory Tests

Animal and laboratory test systems have focused on the possibility that fly ash may cause either cancer or lung scarring.

Carcinogenic Effects

Since fly ash contains quantities of chemicals which are suspected carcinogens, there is concern that fly ash inhalation may produce cancer in human lungs. Several laboratory cell test systems have been used to assess the cancer-causing potential of fly ash. None has indicated cancer-causing activity in fly ash taken from scrubbers or precipitators in conventional coal combustion plants.

Long-term animal studies of fly ash inhalation have not shown any evidence of tumours.[9]

Lung Scarring

Several animal and laboratory studies have looked at the way in which cells of the body's immune system remove fly ash particles from the lungs. If immune cells can remove the particles speedily and effectively, then the risk of developing lung scar tissue is probably low. On the other hand if the immune cells cannot remove fly ash particles quickly from the lungs, inhalation of fly ash may well carry some risk of lung scarring.

Studies with isolated immune cells grown in the laboratory in the presence of small fly ash particles showed that while they could cope with and digest fly ash particles, some of the immune cells were damaged in the process.[10,11] It is by no means certain that this would happen in human exposure. In workplace exposures, the concentration of fly ash present in the lungs is much less than that used in the laboratory test systems.

At least two studies using cell test systems suggest that fly ash particles are much less damaging to the lung immune cells than crystalline silica.[12,13]

Two studies used mice exposed to high concentrations of airborne fly ash, much greater than likely to be found in any workplace. Both studies reported small decreases in the effectiveness of the immune cells of the lungs.[14,15]

Other animal studies looked at the potential of fly ash to damage the cells of the lungs and airways. One of these studies was conducted with monkeys.[9] The monkeys were exposed to between 0.16 and 0.46 milligrams per cubic metre (mg/m^3) of small diameter fly ash. Exposure for several months at these low levels caused no lung scarring.

Another investigation exposed rats to very high concentrations of fly ash for a period of 90 days, followed by a recovery period of a further 90 days. Examination of the lung tissue revealed fly ash particles distributed throughout the lungs, but no overall physical changes to lung tissue. These results have been confirmed by other studies involving monkeys, rats and hamsters.[16,17,18]

IV. FIRE AND EXPLOSION HAZARDS

Fly ash does not burn and is not explosive.

V. CHEMICAL REACTIVITY

Fly ash is not known to react dangerously or violently with other chemicals.

VI. EXPOSURE LIMITS

Many Canadian jurisdictions have exposure limits similar to those established by the American Conference of Governmental Industrial Hygienists (ACGIH). For fly ash ACGIH has established a time-weighted average exposure of 10 mg/m^3.

Consult the appropriate authority in your jurisdiction for specific details.

VII. EXPOSURE CONTROLS

Engineering Controls

Engineering controls are the preferred method for reducing exposure to workplace chemicals. Methods include local exhaust ventilation, process or personnel enclosure, control of process conditions and process modification. Other control methods such as administrative controls or the use of personal protective equipment may also be required.

Respiratory Protection

If engineering controls and work practices are not effective in controlling exposure to fly ash, then wear suitable, approved personal protective equipment. Have appropriate equipment available for use in emergencies such as spills.

If respiratory protection is required, institute a complete, continuing respiratory protection program including selection, fit, testing, training, maintenance, inspection, cleaning and evaluation. Refer to the CSA Standard Z94.4-M1982, "Selection, Care, and Use of Respirators."[19]

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Respiratory Protection Guidelines

Various jurisdictions may have different requirements for respiratory protection for fly ash. Obtain specific information from the appropriate government agency in each jurisdiction.

VIII. STORAGE AND HANDLING

There are no specific measures for the storage and handling of fly ash other than those required for dust control. Contact provincial and local authorities for guidance before disposing of fly ash.

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Note: Additional references on this subject are available from CCOHS upon request.

PLEASE NOTE

This summary was prepared at the Canadian Centre for Occupational Health and Safety (CCOHS) and is intended primarily as a source of information for persons who work with or may be occupationally exposed to this material. The information selected for inclusion is believed to be reliable and generally relevant to occupational health. Other information which bears on particular work situations may be available. The scientific data in many areas are limited and may allow a variety of interpretations. Additional information, corrections, comments and questions are welcome, and should be addressed to the Inquiries Service, CCOHS, 250 Main Street East, Hamilton, Ontario, L8N 1H6, (416) 572-2981; toll free 1-800-263-8276.

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